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The Maine Agricultural Experiment Station

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Fighting the Blueberry Fruit Fly in Maine

F. H. Lathrop

RECOMMENDATIONS FOR CONTROL

For the control of the blueberry fruit fly in Maine the following program is recommended.

Dust the infested, bearing land with 50-10-40 (50 per cent calcium arsenate, 10 per cent monohydrated copper sulphate, and 40 per cent hydrated lime) dust mixture.

Two applications of dust are recommended on land where the larval count of the berries, during recent years, has not exceeded 8 or 10. In rainy seasons, or on land where the larval count has been high, it may be advisable to make 3 applications of the 50-10-40 dust.

The dust should be applied at the rate of 6 pounds per acre at each application.

The first dust application should be made about 7 days after the fruit flies begin to emerge. The flies begin to emerge about the time that the first scattered ripe berries appear.

The second dust should be applied about 7 days after the first rain following the first dust application. The second application should not be delayed longer than 14 days after the first application.

Where 3 applications are to be made they may be spaced at approximately ten-day intervals through the dusting period, but the timing should be varied according to rain during the dusting period. The object is to time the dust applications so as to obtain maximum protection through a period of 20 to 30 days, beginning about 7 days after the first flies emerge.

The dust should be applied only when the air is calm, and the bushes are wet with dew. Conditions for dusting are best in the early morning or late in the evening.

If rain falls within 24 hours after the dust is applied, the dust should be repeated without delay.

Care should be exercised to apply the dust as evenly as practical, at the rate of 6 pounds per acre per application. Too little dust may give unsatisfactory control. Too much dust may injure the blueberry plants, and may result in harmful residue on the berries.

Do not pick the berries from the dusted land until at least 14 days after the last dust was applied.

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ACKNOWLEDGMENTS

Since 1946, Maine blueberry tax funds have been used to support an expanded program of research on Maine blueberries. The research program comprises work on many problems of blueberry production, processing, and pest control, including the study of blueberry fruit fly control.

Appreciation is expressed to all who kindly cooperated and assisted in the research upon which this bulletin is based; especially to the Maine blueberry growers and processors whose generous cooperation made the work possible.

BULLETIN 500

FIGHTING THE BLUEBERRY FRUIT FLY[1] IN MAINE

F. H. Lathrop

INTRODUCTION

During the past 20 years, Maine blueberry producers have combated the fruit fly so successfully that the blueberries sold commercially have been practically free from infestation. The fruit fly remains as an ever present threat, however, and it is important that there should be no let down in the fight against the pest.

The injury caused by the blueberry fruit fly results from the presence of the larvae in the infested berries. The fruit fly larvae are not known to be dangerous to human health, but many people dislike the thought of eating infested berries. The Federal Food and Drug Administration and most State pure food agencies regard the presence of insect larvae as an undesirable adulteration of food products. Strict regulations are enforced against the presence of larvae in blueberries offered for sale. This applies alike to fresh fruit, and to frozen and canned blueberries. The infested product is subject to legal seizure and destruction, and the responsible processor or dealer may be liable to severe penalty.

Aside from such legal considerations, however, it is to the advantage of the Maine blueberry industry to eliminate fruit fly infestation. The general public is becoming increasingly exacting in the matter of quality in food products. If Maine blueberries are to compete successfully with other fruits, it is necessary to continue to produce and market a high-quality product.

The blueberry fruit fly problem first became acute in Maine during the summer of 1924 when it was found that the berries were excessively infested. At that time no method was known for combating the pest, and the blueberry industry was threatened with ruin. To give immediate relief, methods were developed for washing the fruit fly larvae from the berries. It was found, however, that the washing process was time consuming, interfered with canning operations, and reduced the quality of the pack. It became evident that to solve the problem, it was necessary to protect the blueberries from infestation, by controlling the pest on the blueberry land before the berries were infested.

[1] *Rhagoletis pomonella* Walsh.

The Maine Agricultural Experiment Station began observations on the blueberry fruit fly as early as the summer of 1913. Patch and Woods made a study of the life history of the pest in 1922. During the summer of 1925, the Maine Agricultural Experiment Station, in cooperation with the U. S. Department of Agriculture, with the author in direct charge of the work, undertook a thorough study of the biology and control of blueberry fruit fly. The investigation furnished the basis for effective control of the fruit fly, and the blueberry industry was relieved from the threat of a permanent setback. By the summer of 1930, control practices were so well established, the U. S. Department of Agriculture discontinued work on the problem. The Maine Agricultural Experiment Station has continued the investigation since that time. The results of the early years of the investigation have been reported in several publications (6, 7, 8, 9, 10, 11, 15, 16, 21, 22).[2] It is the purpose of the present bulletin to review the essential facts concerning the fruit fly problem, and to report the results of the more recent research.

MAINE BLUEBERRY PRODUCTION

The blueberry fruit fly problem in Maine is so intimately tied in with so many of the operations of blueberry production that it seems worth while to point out briefly some of the factors that influence fruit fly control.

Maine Blueberry Land. Maine blueberries are produced on high, rocky hillsides or on comparatively level, more or less elevated plateau areas or barrens. The soil is variable, generally sandy or gravelly loam, and usually is acid (20).

The blueberry land receives little or no cultural care, except for the periodical mowing of weed bushes, and burning over every two or three years.

Improvements are being made in every phase of Maine blueberry culture. Chemical weed killers are finding increasing usefulness, oil burners are used on some of the land to obtain more economical and thorough burning, chemical fertilizers are coming into use, and experiments are under way to develop methods for more rapidly increasing the stand of blueberry plants. Every practice that can be employed to increase the per acre yield of blueberries has an important bearing upon the control of the blueberry fruit fly and other pests that attack blueberries.

Varieties of Blueberries. The Maine blueberry industry is based almost exclusively upon the production of wild low-bush blueberries. There are a few small developments of wild, high-bush blueberries in

[2] Numbers in parentheses refer to literature cited.

the State, but on the whole, little commercial use has been made of the high-bush berries.

The blueberry industry is concerned especially with two species: the low sweet blueberry, *Vaccinium angustifolium* Ait., and the sour-top blueberry, *Vaccinium myrtilloides* Michx. (*V. canadense* Kalm.). Other species of blueberries have been observed in Maine (3), but they appear to be of little or no commercial importance. The great bulk of production in Maine is of the low sweet blueberries, of which there are many varieties differing considerably in growth habits of the plants, in the shape and size of the leaves, and in the color of the ripe fruit. The plants commonly range in height from 2 or 3 inches on poor land to 6 to 12 inches on the most productive land. The stand of plants also varies from a sparse scattering of isolated plants to compact mats of closely growing plants.

The wide variations encountered in the characteristics of the plants, and the generally wild condition of most of the blueberry land often combine to make precise experimental work difficult.

Picking the Blueberries. Most of the blueberries produced in Maine are picked by means of metal "rakes." In general, the growers do not begin raking until practically all of the berries on the land are ripe; about the second week in August in Washington County, and somewhat earlier farther south and west. When picking begins, the crop is harvested as rapidly as practicable and the season ends with the killing frosts that usually occur late in September. As the berries are raked, they are winnowed in the field, placed in half-bushel boxes, and hauled to the factory for processing.

Yield and Value of Blueberries. The Maine blueberry industry provides a very important source of income for the sections in which the blueberries are produced. The yield from much of the Maine blueberry land is very low. A survey of 239 blueberry farms in Washington and Hancock Counties, reported the average yield in 1924-26 to be about 13 bushels per acre (14). In 1949, a survey of 70 growers, placed the average yield at 23 bushels per acre on first-crop land, and 8 bushels per acre on second-crop land (2). Of course, much higher yields often are obtained, and yields of 100 bushels or more per acre, are produced on the better land. It is evident, however, that it is imperative to keep the cost of pest control operations at a very low figure on much of the blueberry land.

The price paid to growers (2) has varied from $1.48 per bushel during the depression years, 1931-35, to $8.12 in 1946. The price averaged about $4.67 per bushel during the period 1947-49. The average annual value of the blueberry crop sold to Maine processors varied (2) from $431,457 in 1933-37, to $1,979,172 in 1948.

THE BLUEBERRY FRUIT FLY

The blueberry fruit fly (Fig. 1) is a small, two-winged fly somewhat resembling a housefly, but smaller. The fruit fly has a characteristic pattern of dark brown or nearly black bands on each wing. The general

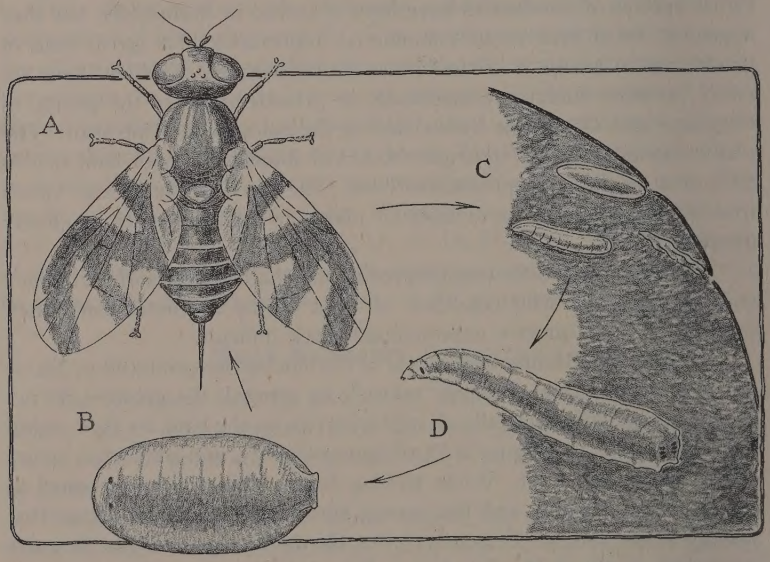

FIG. 1. Life Stages of the Blueberry Fruit Fly.

A is a female blueberry fruit fly. Notice the characteristic pattern of dark bands on the wings. The needle-like ovipositor, by which the fly inserts her eggs under the skin of the blueberry, is shown protruding from the tip of the abdomen. The four light colored bands across the abdomen are characteristic of the female fruit fly. The male has three light colored bands, and the tip of the abdomen is more rounded than that of the female. The natural size is somewhat smaller than a housefly.

B shows the puparium within which the resting stage of the fruit fly spends the winter an inch or two under the surface of the blueberry soil.

C shows a newly deposited egg in normal position just under the skin of a blueberry. Near the egg is an empty egg shell and a very small larva that hatched from it.

D is a full grown larva as it appears when ready to leave the berry and enter the soil. The natural size is about 5/16 of an inch long.

color of the fruit fly is dark brown, marked with gray and white. The male fly has three light colored stripes across the upper side of the abdomen. The female fly has four stripes across the abdomen. The tail

end of the male is more rounded than the female, and the female has a very sharp, egg-laying needle (ovipositor), which can be extended out behind, or withdrawn into the abdomen.

The blueberry fruit fly belongs to the group or "family" of flies known as the Trypetidae, which includes other destructive pests such as the cherry fruit flies, the currant fruit fly, and the Mediterranean fruit fly.

The blueberry fruit fly and the apple fruit fly are exactly alike in every detail, except that the blueberry fly is much smaller than the apple fruit fly. Both flies are technically known as *Rhagoletis pomonella.* In nature, the blueberry fruit fly has not been observed to attack apples, and the apple fruit fly has not been observed to attack blueberries. When very young larvae of the apple fruit fly were artificially transferred to blueberries, the larvae grew normally, but, usually each required two blueberries to complete its growth. The flies that developed were full-sized apple fruit flies. When very young larvae were transferred from blueberries to apples, the larvae developed normally into typical, blueberry fruit flies. It appears that there is a variety or strain of fruit flies that attacks apples, and another closely related, but ecologically distinct strain that attacks blueberries (9, 10, 12, 17, 18). The blueberry grower, therefore, needs to have no fear that apple fruit flies will attack his blueberries. Neither does the apple grower need to fear that blueberry fruit flies are likely to attack his apples.

The blueberry fruit fly attacks not only blueberries, but also most of the other berries found on the blueberry land, including the following species:[3]

Huckleberry, *Gaylussacia baccata* (Wang.) K. Koch.
Dwarf serviceberry or sugar pear, *Amelanchier* spp.
Chokeberry, *Pyrus melanocarpa* (Michx.) Willd.
Bunchberry, *Cornus canadensis* L.
Wintergreen, *Gaultheria procumbens* L.
Mountain cranberry, *Vaccinium vitis-idea* L. var. *minus* Lodd.

Blueberry growers rightly consider such berries as weeds on the blueberry land. Because the weed berries are not picked, they may help to increase fruit fly infestation. The bunchberry may be especially objectionable, because, unlike most of the other kinds, the bunchberry produces fruit on newly burned land.

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[3] The writer is indebted to Professor F. Hyland for advice concerning the use of plant names. The nomenclature follows Gray's Manual of Botany, 8th Edition, 1950.

THE LIFE OF THE FRUIT FLY

The life of the blueberry fruit fly follows a definite course (Fig. 2) that may vary somewhat from year to year, depending upon seasonal conditions (5, 19).

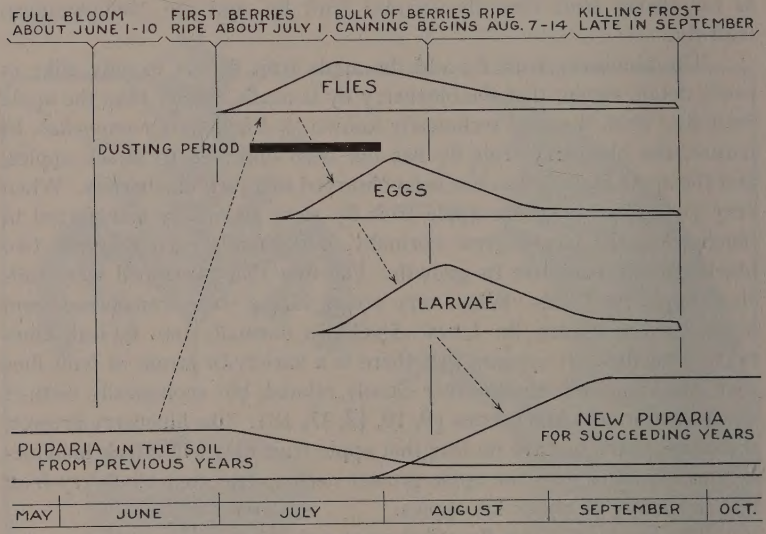


FIG. 2. Seasonal Cycle of the Blueberry Fruit Fly. (For an explanation of the life stages, see Fig. 1.) The dates shown are approximately average dates for Washington County.

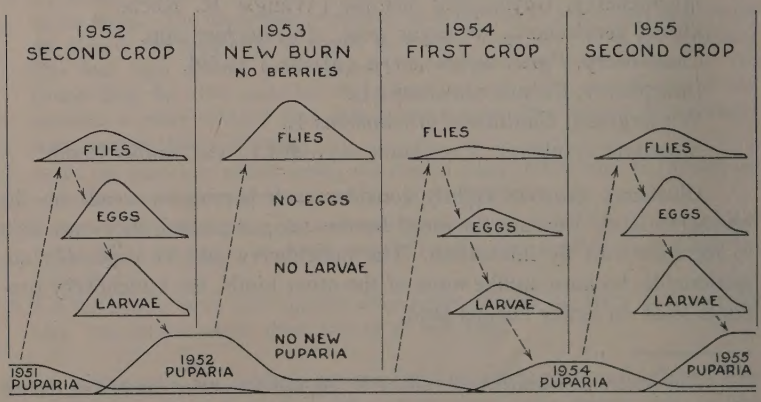


FIG. 3. How Burning Over the Blueberry Land Affects the Seasonal Cycles of the Blueberry Fruit Fly.

The Seasonal Cycle. The insect spends the winter in the soil, in a resting condition, enclosed in a tough skin or shell called a *puparium.* During the last half of June or the first week in July, just at the time when the first blueberries ripen, the fruit flies begin to emerge from the soil. Almost all of the flies emerge within a period of 30 days, but a few straggling flies continue to come out until frost occurs in the fall. After they emerge, the flies loiter among the blueberry plants and on the leaves of any other plants that happen to be on the blueberry land. The flies do not lay eggs immediately, but wait for a period of about 7 to 15 days before they begin to deposit eggs. Egg laying begins when about 3 to 5 per cent of the blueberries are ripe.

When the female fly is ready, she inserts her eggs, one at a time, just beneath the skin of a ripe blueberry. The individual flies, on the average, live about 30 days, and the average female lays eggs during a period of about 15 to 25 days. Because new flies are developing in numbers for a period of about 30 days, the production of large numbers of eggs extends through a period of at least 30 days, and then egg laying continues at a diminishing rate until frost comes in the fall. Observations show that each female fly may deposit from 25 to 100 or more eggs.

The egg is white in color, very small, elongated, round, and bluntly pointed at each end. The eggs hatch in about 7 to 10 days. The small larva, or maggot, that hatches from the egg feeds and grows inside the blueberry (Fig. 1). The individual larvae generally feed for two or three weeks. The full grown larva is whitish in color. It is about 5/16 inch long, round, pointed at one end, and blunt at the other. By the time the larva becames full grown, the pulp of the berry is practically destroyed, and little is left but the skin.

In Washington County small numbers of larvae usually appear in the berries about the middle of July. On land that has not been dusted, the infestation increases rapidly until the heaviest infestation of the berries occurs shortly after picking begins, usually during the second week of August in Washington County. After the middle of August, many of the larvae begin leaving the blueberries, some of the infested berries drop from the plants, and the infestation of the remaining berries declines sharply.

Upon leaving the berries, the larvae enter the soil, and remain through the winter in the resting stage, usually an inch or two beneath the soil surface.

Emergence of the Flies. The time of emergence of the flies determines the proper timing of dust applications for the control of the pest. Because of this importance, detailed studies have been made of emergence.

In order to observe a large enough number of flies to give a reliable indication of the course of emergence, it was necessary to "plant" large numbers of the fruit fly larvae in small plots of soil during August. The next June, before any of the flies emerged, cages were placed over the plots. The cages were observed every day, and as the emergence proceeded, the flies were removed and counted. The apparatus for the observation of emergence of the flies is illustrated in Figure 4.

FIG. 4. Fruit Fly Observation Cages at Blueberry Hill Farm.

Heavily infested blueberries are placed in the large boxes during late summer. The full grown fruit fly larvae drop from the berries through the cloth funnel, and enter the soil where they spend the winter in the resting stage. The large boxes and funnels are removed in the fall. Next summer when the flies emerge from the soil, they are caught in cages like the one shown in the foreground.

Each summer the time of emergence of the fruit flies is given wide publicity. The information helps the blueberry growers to time the application of dust for fruit fly control.

The emergence of the flies follows a characteristic seasonal pattern. At the beginning of emergence, a very few flies appear, and the number of flies increases gradually for several days. Then there is a sharp increase, and large numbers of flies appear daily during the main portion of the emergence period. The flies come out in largest numbers during the middle of the emergence period, or about the time when one

half have emerged. Nearly all of the flies emerge within a period of 30 days, but a few flies continue to come out until fall, when frost stops all activity.

In any locality, the time of emergence of the flies varies somewhat from year to year, depending upon weather conditions (5, 19). The emergence records at Blueberry Hill Farm, Jonesboro, for the five years, 1947 to 1951, are shown in Table 1. At Blueberry Hill Farm, on the average, emergence of flies began about July 1, and the first emergence varied from June 21 (1949) to July 9 (1947). On the average, 50 per cent of the flies had emerged by July 10. The earliest date of 50 per cent emergence was July 1 (1949) and the latest date was July 16 (1947). On the average, practically all of the flies (99 per cent) had emerged by August 2. The earliest date of 99 per cent emergence was July 27 (1948) and the latest date was August 14 (1947).

The emergence dates vary from place to place on the blueberry land, occurring relatively early on early, warm, well drained land, and occurring later on late, cold, comparatively low land. The difference in emergence on medium land and on late land at Cherryfield is shown in Table 2. The emergence observed on the late land ran about 4 to 6 days later than the emergence on the medium land.

Most of the studies of fruit fly emergence have been made in Washington County. Emergence occurs earlier in sections south and west of Washington County. Table 2 shows a comparison of emergence, during 1935, at Cherryfield, in Washington County, and at Kennebunk, in York County. The course of emergence at Kennebunk ran from 9 to 13 days earlier than emergence on the medium land at Cherryfield.

Not all of the larvae that enter the soil during the season emerge as flies during the next season. Some of the larvae remain in the soil for two or more winters, to emerge as flies during later years. It was observed that the number of flies during the second summer may be as great as one fifth of the number that emerged during the first summer after the larvae entered the soil (10). Flies emerged in greatly reduced numbers during the third and even the fourth summer. At blueberry Hill Farm during the years 1947 to 1951, it was found that the number of flies that emerged the second summer ranged from 2.6 per cent to 12.1 per cent, and averaged 6.4 per cent of the first-summer emergence (Table 4). The carry over of flies to the second summer is important for the reason that it enables the pest to remain dormant in the soil during the summer following the burning over of the land when there is no crop of berries for the flies to attack. The flies that emerge during the second summer lay eggs in the first crop of blueberries following the

burn. The second-year flies emerge about five days later in the season than do the first-year flies (Table 3).

The percentage of all flies that were female, emerging in the ob-

TABLE 1

Emergence of Blueberry Fruit Flies at Blueberry Hill Farm Jonesboro, Maine, 1947-1951

Year[1]	Emergence began	Dates when specified percentages of flies had emerged						
		10 per cent	25 per cent	50 per cent	75 per cent	90 per cent	95 per cent	99 per cent
1947	July 9	July 13	July 15	July 16	July 19	July 24	July 31	Aug. 14
1948	July 4	July 11	July 13	July 15	July 18	July 20	July 22	July 27
1949	June 21	June 27	June 28	July 1	July 4	July 7	July 12	Aug. 1
1950	July 3	July 7	July 10	July 12	July 15	July 19	July 22	July 28
1951	June 25	July 2	July 5	July 7	July 9	July 14	July 18	Aug. 3
Average dates	July 1	July 6	July 8	July 10	July 13	July 17	July 21	Aug. 2

[1] The total number of flies observed each year was as follows: 1516 flies in 1947; 1587 flies in 1948; 2528 flies in 1949; 352 flies in 1950; 978 flies in 1951.

TABLE 2

Comparison of the Emergence of Blueberry Fruit Flies at Kennebunk, Maine, and at Cherryfield, Maine, 1935

Locality[1]	Emergence began	Dates when specified percentages of flies had emerged						
		10 per cent	25 per cent	50 per cent	75 per cent	90 per cent	95 per cent	99 per cent
Kennebunk	June 24	July 1	July 3	July 6	July 9	July 12	July 14	July 16
Cherryfield								
Medium land	July 8	July 13	July 16	July 19	July 21	July 23	July 25	July 28
Late land	July 9	July 17	July 20	July 23	July 26	July 29	July 31	Aug. 4

[1] The total number of flies observed at each locality was as follows: Kennebunk, 146 flies, Cherryfield, medium land 1387 flies, Cherryfield, late land 708 flies.

TABLE 3

Comparison of Emergence of Flies that Spent 1 Winter in the Soil and Flies that Spent 2 Winters in the Soil. Records Include 1948, 1949, and 1950 Blueberry Hill Farm, Jonesboro, Maine

	Average dates when specified percentages of flies had emerged							
	Emergence began	10 per cent	25 per cent	50 per cent	75 per cent	90 per cent	95 per cent	99 per cent
Emergence after 1 winter in the soil	June 30	July 5	July 7	July 10	July 13	July 16	July 19	July 29
After 2 winters in the soil	July 5	July 9	July 12	July 14	July 18	July 22	July 27	Aug. 3

TABLE 4

Carry-Over of Emergence of Blueberry Fruit Flies Through Two Years
Blueberry Hill Farm, Jonesboro, Maine

From 1st year	To 2nd year	Number of flies		Percentage carry-over to second year
		First year	Second year	
1947	1948	1516	183	12.1
1948	1949	1587	42	2.6
1949	1950	2528	111	4.4
1950	1951	325	21	6.5
Average				6.4

TABLE 5

Sex of Blueberry Fruit Flies Emerging at Blueberry Hill Farm, 1947-1951

First-Year Flies					Second-Year Flies				
Year of emergence	Number of flies			Percentage female	Year of emergence	Number of flies			Percentage female
	Male	Female	Total			Male	Female	Total	
1947	619	897	1516	59.2					
1948	571	1016	1587	64.0	1948	73	110	183	60.1
1949	831	1697	2528	67.1	1949	29	13	42	31.0
1950	132	220	352	62.5	1950	60	51	111	45.9
1951	397	581	978	59.4	1951	8	13	21	61.9
Average				62.4	Average				49.7

servation cages at Blueberry Hill Farm, ranged from 59.2 per cent to 67.1 per cent (Table 5). Other workers (1, 10) also have observed that more females than males emerged in the observation cages. Observers on the blueberry land, however, usually see more male than female flies. The emergence of the female flies runs a few days ahead of the emergence of the male flies.

CONTROL OF THE BLUEBERRY FRUIT FLY

The blueberry fruit fly is subject to attack by a number of natural enemies that help to keep the pest under control. Two spceies of ants and at least one species of spider captured the flies as they loitered among the blueberry plants (10). Two species of small, wasp-like insects have been observed to lay eggs into the fruit fly larvae within the blueberries (7). Altogether the natural enemies probably are of great importance in keeping the fruit fly pest under control. Such natural control is not sufficient to reduce the fruit fly infestation to the very low level necessary for commercial blueberry production.

In the fight against the fruit fly, Maine blueberry growers employ several practices, including:

Cultural practices
- Suppression of weed bushes
- Burning over the blueberry land
- Clean picking of the blueberry crop

Dusting with insecticides

CULTURAL PRACTICES

The cultural practices are employed primarily to increase the yield of blueberries, but they have an indirect value for fruit fly control.

Suppression of Weed Bushes. Weed bushes such as alder and birch, especially when accompanied by sweet fern and brakefern, furnish protection to the blueberry flies. McAlister and Anderson (12) showed that flies exposed to direct sunshine died sooner than flies kept in shade. It frequently has been observed that blueberries picked within 4 or 5 feet of clumps of bushes may contain 2 or 3 times as many fruit fly larvae as are found in an equal number of berries picked well away from weed bushes. The suppression of weed bushes, on the blueberry land, helps to reduce the fruit fly infestation.

Burning Over the Blueberry Land. The blueberry land is burned over usually every second or third year. The burning is practiced primarily for the pruning and growth-stimulating effects upon the blueberry plants. Burning also exerts an important indirect effect upon the fruit fly (Fig. 3).

The blueberry land is burned over in the spring or in the fall when the plants are dormant, and the fruit flies are in the resting stage in the soil. When properly accomplished, an intensely hot, but very quick fire passes over the blueberry land. The quick blaze kills and burns the stems of the blueberry plants, but care should be used to see that the fire does not eat into the surface layer of organic matter on the soil. Careful studies show that, under proper conditions, the fire used in burn-the blueberry land does not raise the temperature of the soil more than a very few degrees. The resting puparia of the blueberry flies in the soil are safe from injury by the fire. In order to affect the puparia, the fire would burn so deeply the blueberry soil would be injured severely.

Because the resting insects in the soil are not injured by the fire, the blueberry flies emerge normally during the summer following the burn. No crop of blueberries is produced on well burned land during the summer following the burn, however, and the flies die without laying eggs. Except for the comparatively few resting puparia that remain in the blueberry soil until the second summer following the burn, the

fruit fly infestation dies out on the newly-burned land. To be effective against the fruit fly infestation, however, the land should be burned thoroughly. Skips in the burn often bear blueberries that may permit fruit fly infestation to increase during the summer of the burn.

The blueberry flies have not been observed to migrate long distances. Flies from newly burned land do not generally move onto adjoining bearing land much more than 100 feet from the margin of the newly burned area.

Where blueberry land is burned over every third year, a great increase in fruit fly infestation is likely to develop in the berries of the second crop, unless the land is properly dusted. In the two-year system, only one crop of berries is produced between burns, and there is relatively little build up of fly infestation in the single crop of fruit. From the standpoint of fruit fly control, the two-year-burning system seems advantageous. There seems to be a difference of opinion among blueberry growers concerning the relative effects upon the blueberry plants and the productivity of the land.

Clean Picking of the Blueberries. The berries usually contain the greatest numbers of fruit fly larvae about a week after the canneries open. Clean picking at that time helps to reduce infestation on the land. If infested berries are allowed to remain unpicked, the infestation of the land will be increased.

Dusting with Insecticides for Fruit Fly Control

Although other methods, such as burning and clean picking, are important as supplementary control practices, the most effective treatment employed against the blueberry fruit fly is the application of insecticide dusts.

Effectiveness of the Dust Treatment

When research on blueberry fruit fly control was undertaken, it soon was found that calcium arsenate is a cheap and effective insecticide for combating the pest (8). Two applications of calcium arsenate, at the rate of 6 pounds per acre at each dusting, reduced the average infestation of the berries from the dusted areas as much as 90 to 95 per cent, compared with berries from adjacent untreated land (10).

Research on various dust mixtures has been continued through the years, and results of recent tests are presented in Tables 6, 7, and 8. The true value of treatments for fruit fly control cannot be determined fully by experimental tests, but should be judged from the results obtained by practical growers over a period of several years.

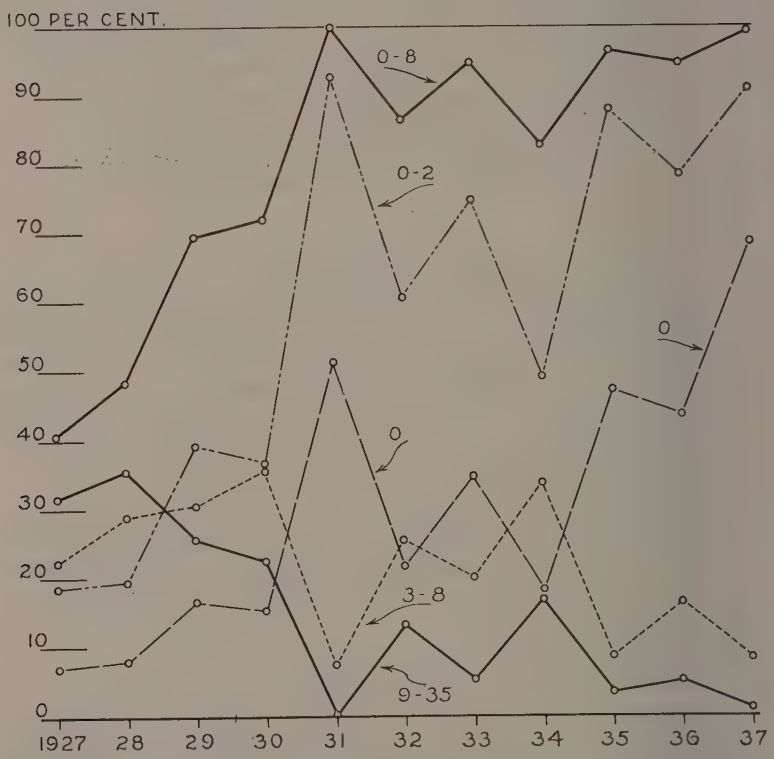


FIG. 5. Larval Counts of Blueberries Received at One Cannery 1927-1937.

In 1927, practically no blueberry land was dusted. Large scale dusting for fruit fly control began in 1928, and was continued every year after that. Notice the increase in the percentage of very clean berries, and the decrease of heavily infested berries as dusting became generally practiced.

Large-scale dusting of the blueberry land for fruit fly control was started in 1928, when about 900 acres of land was dusted in Washington County (4). By 1930, an area of approximately 14,000 acres was dusted. It was estimated that dust was applied to about 18,000 acres in 1937. The effects of the treatments became apparent immediately, as indicated by the larval counts of berries received at the canneries (Fig. 5 and Table 9). It soon became evident that dusting with calcium arsenate gave satisfactory control of the blueberry fruit fly, and during the ten-year period, 1928-1937, dusting became a standard practice for fruit fly control on Maine blueberry land. During the years 1946 to 1951 (Fig. 6 and Table 9), the percentage of very clean berries (larval count 0 to 2)

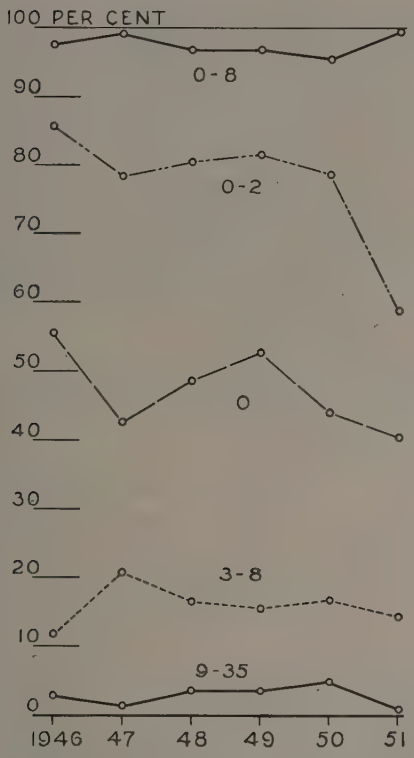


FIG. 6. Larval Counts of Blueberries Received during 1946-1951.
(The cannery was the same as in Fig. 5.)

The percentage of desirably clean berries remained high until 1951, when exceptionally frequent rains during the dusting period made fruit fly control difficult. (See also Fig. 7.)

remained at about 80 per cent of the berries received at the cannery, until 1951, when there was a distinct decrease in the percentage of very clean berries (larval count 0-2), and a corresponding increase in the percentage of moderately clean berries (larval count 3-8). During recent years the percentage of berries with larval count above 8 remained remarkably low. In considering these data, it should be realized, of course, that the situation was influenced by the fact that during recent years the canners have discouraged growers from bringing in berries

with high larval counts. No estimate is available to show how many bushels of berries with high larval counts were refused by the canneries, and discarded, or were allowed to remain unpicked. The fact that the canneries are maintaining a high standard, and that most of the blueberry growers are meeting the high standard is encouraging.

FACTORS THAT INFLUENCE THE EFFECTIVENESS OF THE DUST TREATMENT

It is the general experience of blueberry growers that dusting is not always uniformly effective for controlling the fruit fly. Some of the important factors that influence the effectiveness of the treatments are:

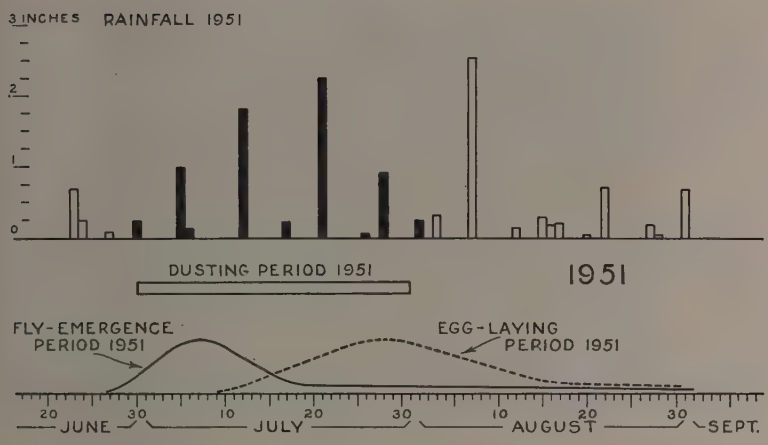
Kind of dust used
Quantity of dust applied
Timing of the applications
Number of applications
Thoroughness of application
Weather conditions during the dusting period.

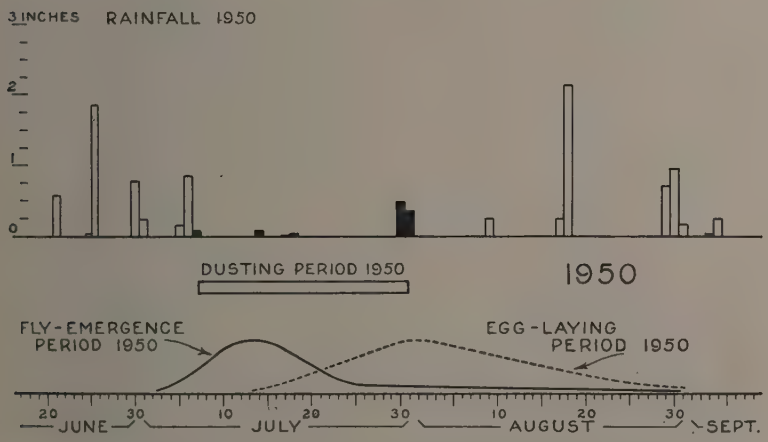
Kind of Dust Used. Until about 1948, straight, unmixed calcium arsenate dust was used for fruit fly control on Maine blueberry land. Because of the injury to the blueberry plants, caused by calcium arsenate, alone, the 50-10-40 (calcium arsenate, monohydrated copper sulphate, hydrated lime) mixture was developed. The development of the 50-10-40 mixture is discussed more fully in the paragraph on Arsenical Injury to the Blueberry Plants. Beginning about 1948, the 50-10-40 mixture rather completely replaced calcium arsenate alone for fruit fly control, and the mixture became the standard dust for fruit fly control in Maine. The data presented in Table 8 show that the 50-10-40 mixture compared favorably with calcium arsenate. Table 9 and figure 6 show that fruit fly control apparently remained at a rather uniformly high level during the years that the 50-10-40 mixture was used, until 1951, when weather conditions during the dusting period apparently had an adverse effect upon the effectiveness of the dust (Fig. 7).

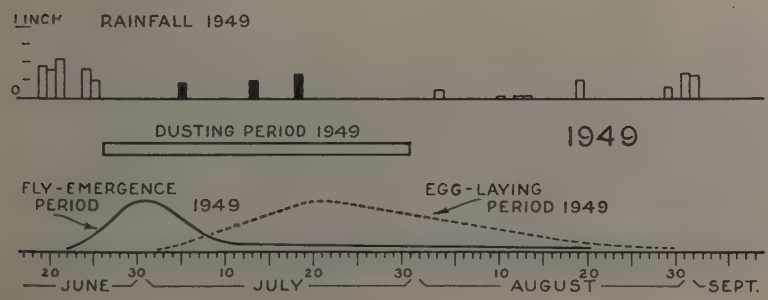
Quantity of Dust Used. The early experimental work showed that 6 pounds of calcium arsenate per acre at each application was quite

FIG. 7. Rainfall in Relation to the Dusting Period at Blueberry Hill Farm, Jonesboro, Maine, 1949-51.

The black vertical bars show the rainfall during the dusting period. The white vertical bars show the rainfall during the time covered by the chart, before and after the dusting period. During the dusting period in 1949 there was a total rainfall of only 0.83 of an inch. In 1950 the total rainfall during the dusting period was 1.02 inch, and in 1951 the total was 6.80 inches.


3 INCHES
RAINFALL 1951
2
1
0
DUSTING PERIOD 1951
1951
FLY-EMERGENCE PERIOD 1951
EGG-LAYING PERIOD 1951
20 30 10 20 30 10 20 30
JUNE
JULY
AUGUST
SEPT.


3 INCHES
RAINFALL 1950
2
1
0
DUSTING PERIOD 1950
1950
FLY-EMERGENCE PERIOD 1950
EGG-LAYING PERIOD 1950
20 30 10 20 30 10 20 30
JUNE
JULY
AUGUST
SEPT.


1 INCH
RAINFALL 1949
0
DUSTING PERIOD 1949
1949
FLY-EMERGENCE PERIOD 1949
EGG-LAYING PERIOD 1949
20 30 10 20 30 10 20 30
JUNE
JULY
AUGUST
SEPT.

effective for fruit fly control (10). Six pounds per acre is a practical quantity for application either by hand duster or by power-driven machines. The standard recommendation, therefore, has remained at 6 pounds of dust per acre.

After the fruit fly infestation had been greatly reduced, some growers found that the quantity of dust could be reduced to as low as 4 pounds per acre, on the comparatively clean land, apparently without noticeable increase in the larval count of the blueberries. The practice of reducing the rate of dust applied is advisable on some land during dry seasons, but probably is not advisable when there is much rain during the dusting period. On most of the blueberry land it is advisable to continue to apply 6 pounds of dust per acre at each application.

Apparently one cause of failure to obtain satisfactory fruit-fly control, is that, unintentionally, too little dust sometimes is applied. Some growers do not know the area of the land to be dusted, therefore they do not know how many pounds of dust shuld be used. Many growers depend upon knowing the rate of discharge of dust from the machine in order to apply approximately the correct amount of dust. The rate of discharge should be increased when the machine moves rapidly over the ground, or if the dust drifts across a wide lane. The rate of discharge from the machine should be decreased when the machine moves slowly, and when the dust is drifted across a comparatively narrow lane.

Each grower should study his duster carefully to be sure that he is applying very nearly the desired rate of dust to his land.

Timing the Dust Applications. The proper timing of the dust applications is an important factor in fruit fly control. The dust is intended to kill the female fruit flies, before the eggs are laid. The flies accidentally take in calcium arsenate as they lap up minute particles, or when they drink droplets of dew from the surface of the dusted leaves. To give maximum protection against fruit fly infestation, therefore, the vegetation should be kept covered with the dust deposit throughout the emergence period of the fruit flies.

The flies begin to emerge as soon as the first scattered blueberries ripen. Egg laying begins in about 7 to 10 days after the flies begin to emerge. The first dust, therefore, should be applied within a period of about 7 days after the berries begin to ripen on any piece of blueberry land. On first-crop land, the dust can safely be delayed a few days later than on second-crop land. This is because most of the flies on first-crop land have carried over two winters in the soil and emerge several days later than do the flies that have spent only one winter in the soil.

After the 50-10-40 dust has been applied, it will remain effective until it weathers off of the plants. A heavy rain may wash off as much

as 75 per cent of the dust. If rain should occur within 24 hours after the dust is applied, the application should be repeated without delay.

The second application of 50-10-40 dust should be made about 7 days after the first rain following the first application. Again, if rain occurs within 24 hours after the second application the dust should be repeated without delay.

A period of at least 14 days should be allowed after the last dust application, before the blueberries are picked.

Number of Dust Applications. In dry seasons, two applications of dust usually have been sufficient to give satisfactory control of the fruit fly. On good blueberry land, it sometimes becomes advisable to make more than two dust applications. In general, a good rule appears to be not to let the land go longer than 14 days between dust applications during the dusting period. In Washington County, the dusting period begins about 7 days after the first blueberries ripen, and extends until about August 1.

On heavily infested land, two applications of dust cannot be depended upon with certainty to assure clean berries. It seems advisable to dust severely infested land three times. In following years, after the infestation has been brought under control, two applications of dust should be sufficient to hold the infestation under control.

When rain follows within 24 hours after dusting, the dust should be repeated without delay, but the two dustings should be counted as one application.

When three dust applications are to be made, they should be about equally spaced through the dusting period.

Thoroughness of Application. The dust should be applied as evenly as practical throughout each piece of blueberry land. Careless dusting is likely to apply too little or no dust in some places, and more dust than needed in other places. The result generally is poor control of fruit fly, and increased injury to the blueberry plants.

Most of the blueberry land is dusted by means of power-driven dusters drawn on trucks. Hand dusters also are used for comparatively small areas.

In 1928 an airplane was used experimentally to dust about 1000 acres of blueberry land in Washington County. Lathrop and Nickels (8) reported that the control of fruit fly was equally effective whether the land was dusted by airplane or by ground machine. In recent years, a few commercial operators have conducted demonstrations of dusting blueberry land with airplane and with helicopter. Although the work of the aircraft is satisfatcory when conditions are favorable, there are several handicaps to air dusting. The cost of aircraft application is exces-

sive, unless large areas are treated. Because aircraft cannot operate in fog, it frequently happens that satisfactory flying time is limited. It is difficult to mark the land so that the areas to be treated can be identified by the aircraft operator.

The general practice is to drive the duster back and forth over the blueberry land along parallel lanes from 100 to 200 feet apart, depending upon the power of the duster, and the distance that the dust will drift at the time of application. The drift of the dust varies with the slope of the land and the amount of air movement.

The dust should be applied only when the air is calm, and the plants are wet with dew. The best time for dusting is in the early morning or late evening. There is practically always slight air movement sufficient to drift the dust. If there is breeze enough to rustle the leaves of birch or alder bushes, the dust will drift too rapidly, and the breeze dries the dew from the plants. When the plants are dry the dust will not stick well to the smooth surface of the blueberry leaves. The new liquid dusters seem promising for applying the dust when the blueberry plants are dry.

Weather Conditions During the Dusting Period. The effectiveness of the dust applied for fruit fly control may be determined to a large extent by the weather conditions that occur during the dusting period. In some seasons, windy weather during the dusting period may make it difficult to properly apply the dust to some of the land.

Frequent rains during the dusting period also may increase the difficulty of fruit fly control. It is generally considered that if a dust application remains for a period of 24 hours before rain falls, the application may be regarded as satisfactory. If rain comes within 24 hours after the dust is applied, the dust should be repeated without delay.

The effect of frequent rains during the dusting period is illustrated in Fig. 6, Fig. 7, and Table 9. Records made at Blueberry Hill Farm, Jonesboro, show that in 1949 there were 3 rains, with a total rainfall of 0.83 inch during the dusting period; in 1950 there were 6 rains, with a total rainfall of 1.02 inches; and in 1951 there were 9 rains with a total rainfall of 6.80 inches during the dusting period. Reference to Fig. 6 shows that in the dry season of 1949, fruit fly was generally well controlled on the blueberry land. In 1950, control apparently was not quite so complete. In 1951, the exceptionally frequent rains (Fig. 7) made it very difficult to maintain an effective dust coating on the plants, and many growers did not fully realize the necessity for repeating the dust applications when followed by rain. The result was that there was a general increase in fruit fly infestation on much of the land. Blueberry growers always should be alert to repeat applications that are washed off within 24 hours, and during exceptionally rainy seasons it is advisable to increase the number of dust applications made to the land.

ARSENICAL INJURY TO THE BLUEBERRY PLANTS

Calcium arsenate dust, when used alone, may cause severe injury to the blueberry plants. The arsenical injury appears as a dark discoloration or "burning" of the tips and margins of the blueberry leaves (Fig. 8). Generally, the injury appears first as a red discoloration on the leaves of the low sweet blueberry, and as a deeper red or purple on

FIG. 8. Arsenical Injury to Blueberry Foliage.

The dark colored "burning" of the margins of the leaves is characteristic of arsenical injury to blueberry leaves. Notice that the burning occurs frequently where the leaves have been injured by leaf-eating insects.

the sourtop blueberry. The sourtop blueberry plants seem to be more susceptible than the low sweet plants. The arsenical injury is most severe around places where insects previously have eaten out portions of the leaves, and on areas where fungus diseases have attacked the leaves. Sometimes it is difficult to decide whether arsenical injury or fungus infection was the primary cause. As the arsenical injury progresses, the margins of the leaves turn deep brown or nearly black, the injured areas of the leaves became dead and dry and the leaves curl. Many of the injured leaves drop from the plants. Where the injury is especially severe, the blueberry plants may lose most of their leaves before the blueberries are picked. Sometimes many of the berries drop from severely injured plants. The prolonged periods of dry weather during the summer of 1949, and again in 1950, aggravated the arsenical injury. The frequent rains during the summer of 1951, reduced the injury. Blueberry land has been observed a number of times on which the arsenical injury had

caused such complete defoliation of the plants, and dropping of the berries, it was evident that the crop was decidedly reduced.

Not only the blueberry plants, but most of the common plants on the blueberry land are subject to arsenical injury. Of all the plants observed, brakefern appears to be most susceptible to injury. The dusted brakes soon turn brown. The injured plants are conspicuous from a considerable distance, and blueberry growers often observe the injured brakeferns to indicate where the blueberry land has been treated with arsenical dust.

Methods for Reducing Arsenical Injury. The injury from calcium arsenate dust is likely to be most severe where the blueberry leaves have been injured previously by leaf-eating insects or by fungus diseases. The application of DDT-ferbam dust when the blueberry plants are in the "cluster bud" stage, and an application of ferbam (without DDT) at petal fall (see the Maine Blueberry Dust Schedule) are recommended to reduce insect and disease injury to the leaves. Experimental tests show that the early-season treatment to combat leaf-eating insects and diseases offers promise for reducing injury from the arsenical dust applied during July for fruit fly control.

As soon as the injury from calcium arsenate became evident, studies were undertaken in an effort to develop a dust mixture that would cause less injury to the blueberry plants. As early as the summer of 1929, a mixture of equal parts of calcium arsenate and hydrated lime was tested, with promising results (6, 11).

One method of avoiding arsenical injury, of course, is the use of a nonarsenical dust. During the years 1936 to 1941, a number of dust mixtures were tested in which the killing agent was rotenone. Rotenone is derived from the ground root of a tropical plant. It is an excellent insecticide against many kinds of insects, and it has the important advantages of low toxicity to plants and to warm blooded animals. Table 6 presents the data from the tests in which rotenone dust mixtures were compared with calcium arsenate. Upon consideration of the data, several points seem clear. Dust containing 0.75 per cent or less of rotenone was not effective for the control of the blueberry fruit fly, under the conditions of the tests. Dust containing 2.0 per cent of rotenone seemed promising. The addition of a suitable spreader-sticker or of terpene ethers and sodium lauryl sulphate improved the 2.0 per cent rotenone dust sufficiently so that the mixtures compared favorably with calcium arsenate for fruit fly control. Unfortunately the outbreak of World War II reduced the supply of rotenone, and attention was transferred to other materials. Perhaps at some future time attention will again be

given to the possibilities of using rotenone for fruit fly control on Maine blueberry lands.

Table 7 shows the results of tests of some miscellaneous materials. The tests were not extensive enough to rule out the possible usefulness of some of the materials included, but none of the miscellaneous materials seemed to show immediate promise of replacing the arsenical dust mixtures for fruit fly control on Maine blueberry land.

Another possibility that appeared promising for reducing arsenical injury was the substitution of copper compounds in place of all or a part of the calcium arsenate in the blueberry dust mixtures. There was a sound basis for considering that the copper compounds might be of value for fruit fly control. Miller and McBride (13) reported that copper carbonate was toxic to the Mediterranean fruit fly, even at very low concentrations. McAlister (11) tested copper carbonate dust for control of the blueberry fruit fly in Maine, with promising results. Mixtures of calcium arsenate, copper sulphate, and hydrated lime, therefore,

TABLE 6

Rotenone Dust Mixtures Compared with Calcium Arsenate for Blueberry Fruit Fly Control

Year	Dust mixture	Size of plot (acres)	Applications[1]		Average[2] larval count (20 ounces of berries)
			No.	Dates	
1936	Rotenone 0.75%	5	2	July 17, 27	9.0
	Untreated check				35.0
1937	Rotenone 2.5%	10	3	July 10, 20, 29	3.0
	Calcium arsenate	10	3	July 10, 20, 29	1.0
1938	Rotenone 2.0%	10	2	July 14, 24	17.0
	Calcium arsenate	10	2	July 14, 24	7.0
1939	Calcium arsenate	10	2	July 16, 23	15.6
	Rotenone 2.0%		1	Aug. 7	
	Calcium arsenate	10	2	July 16, 23	12.6
	Calcium arsenate	10	2	July 16, 23	3.0
	Rotenone 2.0%		1	Aug. 7	
	Calcium arsenate	10	2	July 16, 23	2.6
1940	Rotenone 0.75%	10	3	July 15, 22, Aug. 1	9.0
	Calcium arsenate	10	2	July 15, 22	2.0
	Rotenone 2.0%, Sticker-Spreader 1.0%[3]	10	3	July 15, 24, Aug. 2	7.3
	Rotenone 0.5%	10	3	July 15, 24, Aug. 2	48.0
	Calcium arsenate	10	3	July 15, 24, Aug. 2	9.0
1941	Rotenone 2.0%, Terpene ethers 4.0%, Sodium lauryl sulphate 1.0%	10	3	July 11, 20, 29	1.0
	Lethane-Rotenone[4]	10	3	July 11, 20, 29	2.0
	Rotenone 1.0%	10	3	July 11, 20, 29	2.3
	Calcium arsenate	10	3	July 11, 20, 29	1.3
	Untreated check				7.9

[1] All applications were at the rate of approximately 6 pounds per acre.
[2] Average of 2 or more composite samples, taken from 100 points in each plot.
[3] "DN-181-P" Sticker Spreader, DuPont.
[4] "Lethane 384" 1.8%, Rotenone 1.8%, Röhm and Haas Co.

TABLE 7

Tests of Miscellaneous Materials for Blueberry Fruit Fly Control

Year	Dust mixture	Size of plot (acres)	Applications[1]		Average[2] larval count (20 ounces of berries)
			No.	Dates	
1942	Pyrethrum derivative[3] 50% Talc[4] 50%	10	3	July 9, 17, 25	6.5
	Pyrethrum derivative[5] 10% Sodium fluoaluminate[6] 90%	10	3	July 9, 17, 25	7.5
	Calcium arsenate	10	3	July 9, 17, 25	9.3
					2.0
1947	DDT (No. 1)[7] 5%	4	2	July 15, 30	5.0
	Untreated check				10.0
	DDT (No. 2)[8] 5%	4	2	July 15, 30	3.0
	Untreated check				10.0
1950	Methoxychlor 10%	10	2	July 11, 19	29.0
	Untreated check				100.0

[1] All applications were at the rate of approximately 6 pounds per acre.
[2] Average of 2 or more composite samples, taken from 100 points in each plot.
[3] "Stimtox A," John Powell and Co.
Pyrethrins 0.5%
Petroleum hydrocarbons 3.0%

[4] Eastern Magnesia Talc Co.
[5] "Pyrocide," McLaughlin Gormley King Co.
[6] "Kryocide," Pennsylvania Salt Mfg. Co.
[7] DDT (No. 1)

DDT 50% concentrate	10%
Talc	70%
Monohydrated copper sulphate	10%
Lime	10%

[8] DDT (No. 2)

DDT 50% concentrate	20%	A
Talc	80%	
Monohydrated copper sulphate	50%	B
Hydrated lime	50%	

Equal parts of A and B were mixed together immediately before the dust was applied.

appeared to be worthy of consideration for blueberry fruit fly control. Table 8 presents the results of tests of calcium arsenate alone in comparison with arsenic-copper-lime dust mixtures. As may be expected, the data in Table 8 show considerable variability. A careful study, however, shows that the 50-10-40 dust mixture compares favorably with calcium arsenate alone for fruit fly control, and some of the tests suggest that the mixture may be even more effective than calcium arsenate alone.

Observations over a period of seven years show that the 50-10-40 mixture is decidedly less injurious to the blueberry foliage than calcium arsenate alone, and somewhat less injurious than a mixture of equal parts of calcium arsenate and hydrated lime, without copper sulphate. Mixtures of zinc sulphate and of magnesium sulphate with the calcium arsenate-lime combination were tested as agents for reducing arsenical injury to the blueberry plants. Neither zinc sulphate nor magnesium sulphate reduced injury to the foliage as effectively as copper sulphate.

In preparing the 50-10-40 dust mixture, monohydrated copper sulphate generally is used. There are several reasons for this. One reason

is because monohydrated copper sulphate is manufactured in the form of a fine powder that is more readily incorporated in the dust mixture than is the ordinary, crystalline copper sulphate. The tests showed that the calcium arsenate-lime combination with monohydrated copper sulphate was somewhat more effective for fruit fly control than was the combination in which the basic copper compound replaced the monohydrated copper sulphate. Generally the monohydrated copper sulphate mixture has been cheaper in price than the basic copper mixture. The monohydrated copper sulphate mixture has the one objectionable feature that it

TABLE 8

Calcium Arsenate Compared with Arsenate-Copper-Lime Mixtures for Blueberry Fruit Fly Control

Year	Dust mixture	Size of plot (acres)	Applications[1]		Average[2] larval count (20 ounces of berries)
			No.	Dates	
1943	20-20-60[3]	10	3	July 10, 19, 29	0.5
	80-7-13[3]	10	3	July 10, 19, 29	0
	Calcium arsenate	10	3	July 10, 19, 29	2.0
1945	50-10-40[3]	15	2	July 12, 25	1.0
	50-10-40[4]	15	2	July 12, 25	3.8
	Calcium arsenate	15	2	July 12, 25	3.5
1946	50-10-40[3]	10	2	July 13, 26	5.7
	30-10-60[3]	10	2	July 13, 26	3.3
	Calcium arsenate	10	2	July 13, 26	1.3
1947	50-10-40[3]	5	2	July 15, 30	0
	Calcium arsenate	5	2	July 15, 30	2
	Untreated check				5
	50-10-40[3]	5	2	July 24, Aug. 2	23
	Calcium arsenate	5	2	July 24, Aug. 2	10
	Untreated check				147
	50-10-20-20[5]	5	2	July 15, 30	7
	Untreated check				9
1948	50-10-40[3]	10	2	July 15, 30	6
	Untreated check				12
1949	50-10-40[3]	4	2	July 8, 17	5
	Untreated check				8
	50-10-40[3]	4	2	July 8, 19	3
	Untreated check				28
	50-10-40[6]	4	2	July 8, 17	7
	Untreated check				16
	50-10-40[6]	5	2	July 8, 19	8
	Untreated check				12
	Calcium arsenate	4	2	July 8, 16	1
	Untreated check				3
	Calcium arsenate	4	2	July 8, 19	12
	Untreated check				21
1950	50-10-40[3]	4	2	July 11, 19	17
	Untreated check				76
	50-10-40[3]	4	2	July 11, 19	16
	Untreated check				74

[1] All applications were at the rate of approximately 6 pounds per acre.
[2] Average of 2 or more composite samples, taken from 100 points in each plot.
[3] The numbers refer to calcium arsenate–monohydrated copper sulphate–hydrated lime, respectively.
[4] The numbers refer to calcium arsenate—basic copper sulphate—hydrated lime, respectively.
[5] The numbers refer to calcium arsenate—monohydrated copper sulphate hydrated lime—talc, respectively.
[6] The numbers refer to calcium arsenate copper oxychloride—hydrated lime, respectively.

TABLE 9

Summary of Inspector's Reports from a Blueberry Cannery in Washington County, Maine, Showing the Percentage of Berries Containing Specified Numbers of Larvae 1927-1937 and 1946-1951[1]

Year	Number of larvae in 20 ounces of berries					
	0	0-2	3-8	0-8	9-35	36+
1927	7.0	18 5	22.1	40.7	31.7	27.6
1928	7.9	19 4	28.9	48.2	35.3	16 5
1929	16.5	39.1	30.4	69.5	25.5	5 0
1930	15.3	36.6	35.4	72.1	22.4	5.5
1931	51.1	92.6	7.3	99.9	0.1	0
1932	21.8	60.7	25.5	86.2	13.1	0.7
1933	34.6	74.6	20.0	94.5	5.1	0.4
1934	18.1	49.1	33.6	82.8	16.7	0.5
1935	47.1	87.7	8.5	96.1	3.3	0.6
1936	43.5	78.3	16.2	94.5	5.0	0.5
1937	68.5	90.8	8.2	99.0	1.0	0
1946	55.4	85.5	11.8	97.3	2.7	0
1947	42.4	78.2	20.7	98.9	1.1	0
1948	48.5	80.2	16.4	96.6	3.4	0
1949	52.7	81.3	15.4	96.7	3.3	0
1950	44.0	78.4	16.7	95.0	4.8	0.2
1951	14.2	58.9	40.3	99.2	0.8	0

[1] In 1927, practically no blueberry land was dusted in Maine. Large scale dusting for fruit fly control began in 1928. The data include records from a total of approximately 511,000 bushels of blueberries received at the cannery.

is likely to "set" into a very hard mass, and be unusable if it is kept in storage for a long time.

Considered from all angles, however, the 50-10-40 dust, composed of 50 per cent calcium arsenate, 10 per cent monohydrated copper sulphate, and 40 per cent hydrated lime, appears at the present time to be the most generally satisfactory dust mixture for blueberry fruit fly control.

Residues on the Harvested Blueberries

In applying insecticides to the blueberry plants, for the control of fruit fly, growers should exercise care not to apply excessive quantities of dust. Excessive applications are likely to injure the blueberry plants, and may leave too much residue on the berries at picking time. Throughout the investigations of fruit fly control, consideration has been given to the possibility of harmful residues on the fruit. Chemical analyses have been made from time to time of ripe blueberries picked from the experimental plots. The results of many of the analyses are given in Tables 10 and 11.

In general, the analyses show the arsenical residue (As_2O_3) on the berries to be well below any quantity generally considered injurious to human health, even where full strength calcium arsenate was applied. In a few of the samples, however, the arsenical residue approached what

might be considered a dangerous limit, and in one sample the arsenical residue (11.75 p.p.m.) was well above the limit that is generally considered permissible in food products.,

Fortunately, as shown in Table 11, the 50-10-40 dust mixture—now generally used for fruit fly control—has greatly lessened the danger of excessive arsenical residues on the ripe blueberries. The use of the 50-10-40 mixture, however, has introduced the problem of excessive copper residue. Copper residue is generally considered much less injurious to human health than is arsenical residue. The copper residues shown in Table 11 apparently are not conidered harmful.

TABLE 10

Arsenical Residue on Blueberries from Applications of Calcium Arsenate for Blueberry Fruit Fly Control[1]

No. of applications	Total dust applied (lbs. per acre)	Date samples picked	Days since last application	Residue As_2O_3 (p.p.m.)
		1926		
1	11.40	Aug. 2	9	1.04
2	18.15	Aug. 4	8	1.37
3	25.41	Aug. 4	0	2.00
3	27.90	Aug. 30	20	3.86
4	30.85	Aug. 21	9	5.15
4	30.85	Aug. 21	9	3.00
4	38.33	Aug. 31	18	1.57
		1927		
2	12.91	Aug. 5	7	0.572
2	12.91	Aug. 5	7	0.572
2	12.91	Aug. 13	15	Trace
2	12.91	Aug. 13	15	Trace
2	8.84	Aug. 23	23	Trace
2	8.84	Aug. 23	23	Trace
2	8.84	Aug. 23	23	Trace
2	12.11	Aug. 3	8	5.72
2	12.11	Aug. 3	8	0.572
2	12.11	Aug. 10	15	Trace
2	12.11	Aug. 10	15	Trace
2	13.09	Aug. 4	7	0.858
2	13.09	Aug. 11	13	2.00
2	13.09	Aug. 18	20	Trace
2	12.72	Aug. 4	7	1.57
2	12.72	Aug. 11	13	1.00
2	12.72	Aug. 18	20	1.00
2	12.72	Aug. 18	20	1.00
		1928		
2	13.2	Aug. 15	17	1.10
2	13.1	Aug. 16	19	1.38
2	14.48	Aug. 15	15	1.93
2	18.78	Aug. 15	17	5.15
1	6.8	Aug. 20	30	1.43
1	4.6	Aug. 17	27	0.10
1	6.6	Aug. 16	20	0.97
1	8.34	Aug. 29	33	1.72
2	13.36	1929		
2	13.40	Aug. 5	7	1.50
		Aug. 5	8	1.68

[1] Data from Lathrop and Nickels (10).

TABLE 11

Arsenical and Copper Residues from Applications of Calcium Arsenate and Mixtures of Calcium Arsenate, Monohydrated Copper Sulphate, and Lime[1]

Composition of dust (per cent)		No. of applications	Total dust applied (lbs. per acre)	Date samples picked	Days since last application	Residue As_2O_3 (p.p.m.)	Residue metallic copper (p.p.m.)
				1943			
Calcium arsenate	20						
Monohydrated copper sulphate	20	3	18	Aug. 10	12	0.38	3.12
Hydrated lime	60						
Calcium arsenate	80						
Monohydrated copper sulphate	7	3	18	Aug. 10	12	0.72	5.0
Hydrated lime	13						
Calcium arsenate		3	18	Aug. 10	12	0	0
				1947			
Calcium arsenate	50						
Monohydrated copper sulphate	10	2	14.6	Aug. 13	14	0.8	7.22
Hydrated lime	20						
Talc	20						
Calcium arsenate	50	2	11.8	Aug. 15	14	0.8	6.11
Monohydrated copper sulphate	10						
Hydrated lime	40	2	11.8	Aug. 13	14	0.95	5.5
Calcium arsenate		2	12.3	Aug. 15	14	11.75	0
Calcium arsenate		2	11.2	Aug. 13	14	3.8	0
				1948			
Calcium arsenate	50						
Monohydrated copper sulphate	10	2	12.2	Aug. 20	25	0.3	0
Hydrated lime	40						

[1] Data from analyses made by the Department of Chemistry, Maine Agricultural Experiment Station.

The fact that most of the Maine canneries now wash the blueberries thoroughly before they are processed, also decreases the danger of harmful residues on the canned or frozen fruit.

Growers and processors should realize, however, that great excesses of insecticide residues are very difficult to wash from the berries. The presence of excessive residues may lead to condemnation of the blueberries by pure food authorities. Care should be exercised not to apply excessive quantities of the dust to the land for fruit fly control. Berries should not be picked from the dusted land sooner than 14 days after the last dust application. In very dry seasons, a longer period should be allowed before the berries are picked.

COST OF DUSTING OPERATIONS

The cost of dusting blueberry land varies considerably, depending upon the size of plots to be dusted, and whether there are several plots

close together or the single plots are widely separated. The character of the land, and weather conditions during the dusting period also influence the cost of dust application.

A power-driven duster can treat from 15 to 40 acres per hour. Two or three men, a truck and a power duster are required. Dusting large areas of land, of course, can be done more economically than dusting small, isolated areas. Dusting rough land consumes more time than treating an equal area of relatively smooth land. Wind and rain sometimes hamper operations and increase the cost of dusting.

Lathrop and Nickels (10) estimated the cost of dusting in 1929 to be about 82 cents per acre for each application, including all expense, except the cost of the dust. In 1952 the cost of labor and machinery is higher than in 1929. The present use of trucks has increased the efficiency of operation, however, compared with the horse-drawn equipment used in 1929. Present estimates place the cost of dusting between 90 cents and $1.00 per acre per application, not including the cost of the dust. The 50-10-40 dust sells at prices ranging from 7 to 10 cents per pound, making the total cost of dusting $1.32 to $1.60 per acre for each application.

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